

Paper 601: Climate Analysis and Strategies for Bioclimatic Design Purposes

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Abstract

The climate data information available for architectural design variables is either derived from climatology science or from empirical knowledge domain. From this stand point of view, one can ask: - is it the architectural practice aware of this? This paper is about the most needed information that architects should be aware of whenever climate affects one architectural object, and it is always needed. It is a matter of concern, for architectural design purposes, the recognition of climate elements that should be tackled to avoid unnecessary energy waste and human discomfort in the built environment, this because of both; misleading information available and architects ignorance on the matter. The paper is concerned with the temperature and the humidity as the main climatic elements that affect comfort and energy savings. It is suggested a climate classification based the psychrometric chart to assess those variables. The work is aimed to students and professionals working with the design of the environment for the human comfort and the strategies for energy savings to achieve comfort.

Keywords: *climate classification, design strategies, bioclimatic architecture*

1. Introduction

The objective of this paper is to open up a discussion on teaching the climate analyses for bioclimatic design purposes. Also the initial design measures for human comfort indoors and strategies related to deal with climate adversities. So, climate classification here is a climate general understanding for design decision making in the first steps of the building design.

The built environment is the buildings, the streets, the cities. It is also the open area around, between and inside buildings. The built environment is the world where man lives. Open or enclosed spaces, indoors or outer buildings should always promote comfort for its inhabitants. [1]

The bioclimatic chart is the first and perhaps the most important illustration produced as a tool for architect education. The diagram shows the relationship between built environment and the human comfort. [2]

Despite its wide usefulness the bioclimatic chart seems to be understood only by experts and students or even experienced professional do not make use of this design "tool". The chart is helpful to demonstrate a concept instead of a sensible design tool.

Bioclimatic architecture is one way of seeing the relationship between the built environment and the human comfort.

The climate is what is perceived as local environment resulting from temperature, humidity, solar radiation, wind, rain and so on, all of them interconnected. But there is a scale of importance of these elements in relation to human comfort because they are to be found differently according to its manifestation in "loci", in the earth planet. So for human comfort and design purposes, what are the climatic elements that should be considered when designing the built environment? Is there a scope for climate classification to identify the different climatic elements and their relative influence in different regions of the planet? The architectural thinking takes into account several design variables is it the climate one of them? Against the climate adversities for human comfort what are the design strategies to be achieved? Is it possible to design with the climate for human comfort? This paper is about temperature, humidity, design strategies to achieve comfort in the built environment and also it deals with a tool, the psychrometric chart to aid architects take decisions in the early stages of the design process. [3]

2. The built environment and the human comfort

The bioclimatic chart is one of finest drawings prepared to show what comfort in the built environment means whenever one try to explain the relationship between environment elements and human comfort. From the drawing it is also

possible to understand that the all parameters involved in the concept of comfort act together in different proportion. Also and most important, the concept of comfort is evoked by using two axes one vertical showing the variable temperature and another horizontal for the humidity variable (see Fig 1 bellow).

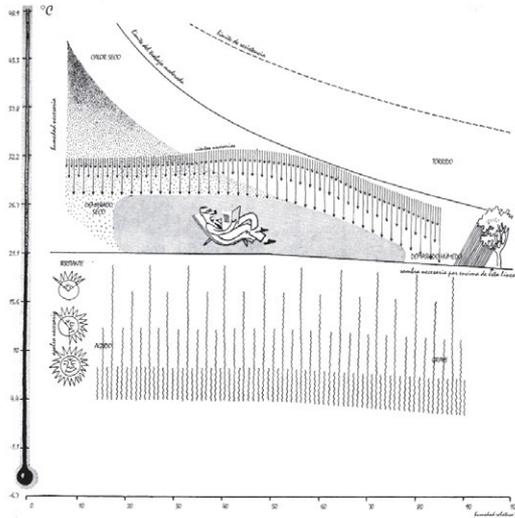


Fig 1. The Bioclimatic Chart

3. The elements of climate and the architecture welfare for a bioclimatic approach

The human perception of the environment is initially visual and then thermal because one determines the relative position in the space and the other indicates the thermal appropriateness of the space for human existing or conditions of it.

The mental and cultural aspects of designing the spaces are the field of architecture. Architecture is meant to offer spatial solution that goes further than thermal comfort. In fact, thermal comfort is something that is inherent to the architectural spatial solution. In essence if there is no thermal comfort no architecture exists. Thus human thermal comfort in the built environment must be achieved in one way or another. It is possible to qualify architecture proposals by evaluating the thermal conditions that can be found in architectonic space solutions. [4]

3.1 The temperature and the humidity in the built environment

When man is experiencing the built environment the air temperature is perhaps the most noticeable climatic element, in other words, man is always aware of air temperature. The human body alarm is turned on if the air temperature is too cool or too hot. The human body is very sensitive to environment thermal variations and needs a stable internal temperature and the body behavior in relation to temperature variations of the environment. It is not a question of choice but survival. Therefore, the environment temperature

is a matter for concern as a climatic element for human comfort. [5]

The temperature and moisture content of the air are strictly coupled. Hence dealing with thermal comfort means dealing with temperature and humidity. The other comfort parameters are matters that can and should be dealt with the control of temperature and humidity within a range of acceptable temperatures for comfort without stress.

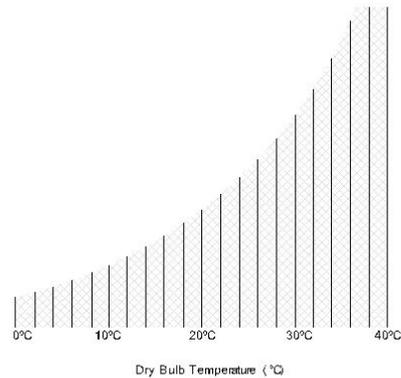


Fig 2. Temperature lines – the psychrometric chart

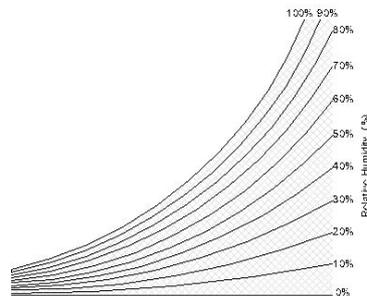


Fig 3. Humidity lines – the psychrometric chart

The humidity is a problem for human comfort whenever it is associated to high temperatures. High air temperature must be dissipated and once the air masse is saturated with moister content then the high humidity “traps” the temperature. [6]

High temperature and humidity do not allow for body transpiration which is an impediment to body heat exchange and internal body temperature stabilization which is necessary for its functioning.

On the other hand, low temperature coupled with any level of moisture content does not cause a real problem of comfort.

3.2 The psychrometric chart

The psychrometric chart allows for several deductions which affect the design of the built environment. Because it relates, amongst other aspects of temperature and moisture content in the air, it is possible to draw areas of different influences of these variables. Also the psychrometric chart can serve as basis for climate classification and building design strategies according to temperature and humidity.

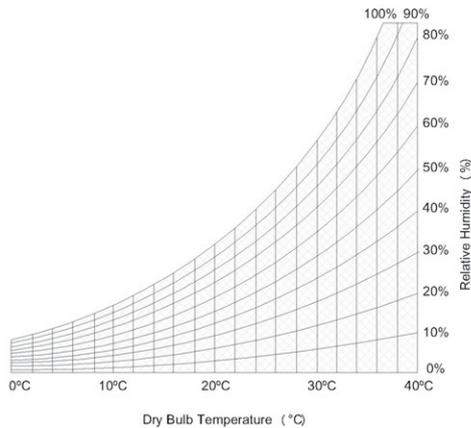


Fig 4. Psychrometric chart - showing lines of temperature and relative humidity

4. The climate classification for design purposes

A simple method to classify the climate for design purposes through mean monthly temperature and humidity with the aid of the psychrometric chart is to establish four categories: (1) cool, (2) temperate, (3) hot and humid and (4) hot and dry (Fig 5). This is not a definite classification this is intended to give designers an easy and general overview of the temperature and humidity effect on building demands for human comfort. Aroztegy [7] proposes a more detailed climate analyses and classification based on temperature amplitude also does Marsh [8], this time based on high and low humidity associated to mild temperatures in the corresponding 'temperate' area here proposed. The exact subdivision is not the discussion. The classification is to judiciously call designers attention for the importance of the role of these variables in design decision making, in the very early stages of the building design based on straightforwardly and simple available climatic data, local mean monthly temperature and humidity.

The climate classification here has to do with the designers domain of the climate for design purposes, which means the need the architect has to understand climate variations, or temperature and humidity variations influencing and been influenced by the built environment [2].

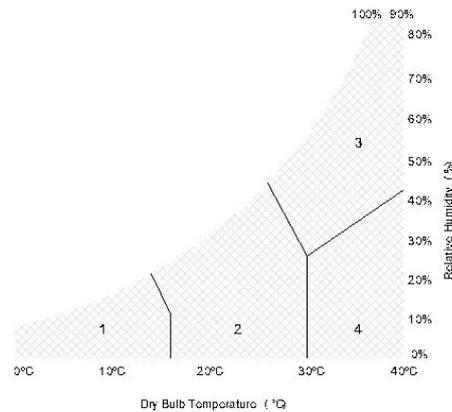


Fig 5. Psychrometric chart – climate areas

The areas in the figure were determined considering one range of temperature to associate it to temperate climate, between 16° and 28°C. The cool area in the chart corresponds to temperatures below 16°C. Above 30°C the level of moisture content in the air, starts to be important for determining human comfort because of the association of the high temperature to humidity. So it is necessary to establish two areas of high temperature; one the hot and humid area with relative humidity levels above 50% and another with humidity below 50%, the hot and arid conditions. In early stages of the design process this is very important to take into account because this is the preliminary aspects to determine comfort, the choice of materials of construction to be specified for the building elements, the fenestration (size, form and orientation of the apertures in the building envelope), and the insulation of the walls, and so on.

This climate approach to design is enough to give the architect the necessary confidence to start spatial proposals without umpiring prejudice of comfort. [3]

5. The strategies to deal with climate adversities for human comfort in the built environment

Delimited areas in the psychrometric chart can be determined for design strategies in the same way the areas of the chart can show climate classification for design purposes. In order to have these areas in the chart corresponding to design strategies one should draw the area where a range of temperatures and humidity variation is accepted for comfort. By drawing that "zone of acceptable temperatures and humidity for comfort" temperature and humidity can be related to design strategies [9]. The more detailed the data the more precise are the areas (the strategies). The border lines of these areas are subject for design investigation in both situations for analyzing climate and strategies.

A general approach can be made by drawing eight areas: (1) active heating, (2) passive heating, (3) humidification, (4) evaporative cooling, (5) dehumidification, (6) thermal inertia (through thermal mass of the building), (7) ventilation and (8) “active cooling” or the use of HVAC (Fig 6), the darker shaded area in the middle of the diagram is to be considered a general comfort area [10].

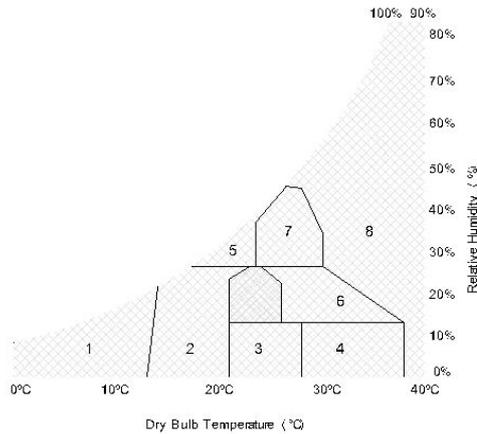


Fig 6. Psychrometric chart – design strategies areas

6. The design strategies and the architectural invention

There is no guarantee of a good design by using the psychrometric chart as a tool to understand climate and determining design strategies, nevertheless the use of the chart allows for confidence when dealing with climate and design strategies. [7]

The architectural invention goes beyond climatic aspects of the design. The proposed approach to climate suggested in this work aims to alert those involved with design of the built environment mainly students, to take in to account some basics of the comfort and climate questions of the planning and the architectural project. A detailed work to understand atmosphere near the ground, micro or biometeorological can be found elsewhere. [11]

Following is an example to illustrate climate classification and design strategies to a given temperature and humidity monthly variation for a certain locality.

The example of climate classification and the design strategies appropriate to a climate has taken the mean monthly temperature and humidity from a work on typical day of project developed to the Porto Alegre climatic region in southern Brazil. [12]

The general idea is that any designer can use available data for a specific location and get the feeling of the climate by plotting it in the psychrometric chart (climate classification Fig 5

and design strategies Fig 6), in order to start designing.

Table: Example given for climate data use to climate classification and design strategies identification

Climatic Data	Mean Monthly	
	Temperature(°C)	Humidity (%)
JAN	24.7	71
FEB	24.6	74
MAR	23,1	76
APR	19.9	77
MAY	17.0	81
JUN	14.7	82
JUL	14.3	81
AGO	15.2	79
SEP	16.8	78
OCT	19,1	75
NOV	21.2	71
DEC	23.4	69

It is important to emphasize that this is a starting procedure to classify the climate for designing purposes. At this point in time the cool, the temperate, the hot humid or the hot dry areas in the graph should be understood as flags of vigilance for design decisions. Therefore, during the process of designing more detailed aspects of the climate and its feature can be incorporated into the project.

Figure 7 shows mean monthly temperature and humidity plotted in the psychrometric chart. From the figure is possible to see that the plotted area expands from about 14 to 25°C this within a humidity variation of 70 to 80%. It represents a mild climate, with temperate aspect. The temperate here is according to the climate classification proposed.

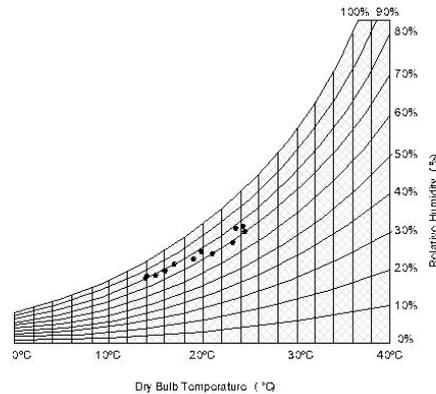


Fig 7. Example given for climate classification and for design purposes – Porto Alegre’s climate data plotted in the psychrometric chart

Figure 8 shows that June and July temperatures fall into the cool area of the diagram. Nevertheless this is not the main climate behavior. The main feature of the climate is represented by temperature and humidity that fall in the temperate area of the illustration. Nevertheless, two months of a “cool” climate appears this causes active measures for comfort

and this is a very clear sign of alert for architect attention and design measures for this climate behavior.

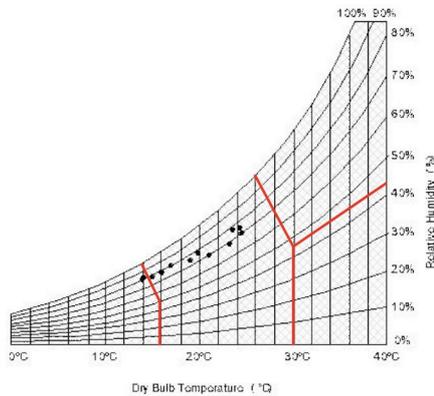


Fig 8. Example given for climate classification for design purposes – Porto Alegre's mean monthly temperature

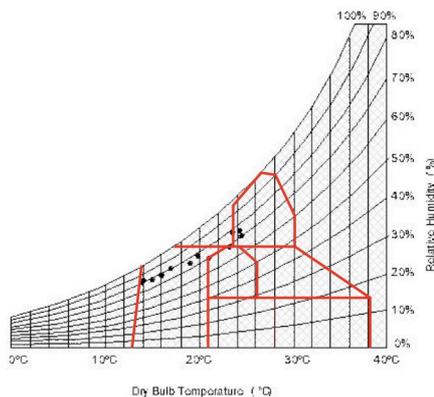


Fig 9. Example given for design strategies to be considered for design purposes – Porto Alegre's climate data plotted in the psychrometric chart

7. Conclusion

The paper has shown the importance of temperature and humidity and a basic approach to these climate elements to promote better built environment. The climate understanding through the psychrometric chart relates temperature and humidity and makes possible a climate classification and the possibility to foresee design strategies to achieve comfort at early steps of the architectural design process. [13]

Some studies show other parameters involved in the bioclimatic approach of the built environment. This study about climate classification has taken into consideration mainly the built enclosed areas. [14]

More detailed climatic data for temperature and humidity analysis can be found in studies of

several cities in the world. The example used to show the approach suggested has used the mean monthly temperature and relative humidity. [15]

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